Transactions of the Materials Research Society of Japan 24 [3] 291-294 (1999)

Science Education to Learn about Scientists —Possibility of Materials Use of the History of Science—

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This paper discusses the necessity of citizens understanding science and technology from the perspective of science studies and pedagogy. It also deals with the significance and methodology of using the history of science as an aspect of science education. In addition, this paper also shows the outline of the teaching material,"How Scientists to Be : The History of Dispute on the Hereditability of Intelligence" developed by the author, and the changes of images of scientists that university students had after learning the above material. They were able to have a deeper understanding of : (1) the relationship between research activities of scientists and societal and cultural situations, (2) research methods and the subjectivity of scientific knowledge obtained from research.
Key words : Science Education , the History of Science , Images of Scientists

1. INTRODUCTION

The Curriculum Council reported to the Minister of Education on the improvement of standards of the curriculum for schools in July, 1998. The report recommends setting up a new subject called "Rika Kiso (Science Foundation) " in the high school curriculum. It will allow students to learn the history of science and the relationship between science and the lives of human beings. Because this subject is optional only some, not all, students will benefit from it.

The history of science has hardly been emphasized in the science education curriculum in the Japanese school system. Teaching the history of science will be the first experience for most science teachers. The number of science teachers using the history of science in their courses is limited in Japan. The same can be said about the U.S.A.[1] Japanese educators who are well versed in the history of science have advocated the significance of introducing it into science education for many years[2]. Although HOSC and HNST have been introduced in Japan, the history of science is yet to be taught in the Japanese school system mainly because of the lack of training teachers for it.

The history of science is scheduled to be taught in high schools starting in 2002. This paper will study the significance of learning the history of science from an educational point of view, so that learning it will not be reduced to the rote memorization of a chronological table. This paper will also propose the use of the teaching material developed by the author as one of the possible methods capable of giving significance to teaching the history of science.

2. SCIENCE AND TECHNOLOGY FOR CITIZENS

2.1 The role of citizens in science and technology

No one can spend a single day without being involved in science and technology in this civilized society, consciously or unconsciously, whether one likes it or not. There are mounting concerns among not only critics of science but also among scientific communities as well as many ordinary citizens about what new technology such as cloning and atomic power generation should be like. In the wake of the great Hanshin-Awaji Earthquake and the incident of planting sarin gas in the subway in 1995, people's distrust in scientists, technical experts and specialists grew.

Kiku(1996) says in the outline for the Basic Law on Science and Technology, promulgated and enforced in November 1996, that opportunities for dialogues between scientists and citizens should be increased so that citizens could think of the relationships between society and science and technology. Getting close to science and promoting science and technology can be good for human beings and society[3]. Ikeuchi, a scientist, (1996) also stresses the importance of long-lasting dialogues between citizens and scientists. He says effective use of science and technology requires the formation of dialogues between experts and citizens[4]. In contrast, Watson(1996) insists dialogues are not necessarily required[5]. He says that he has no intention to look for trouble by appearing in front of non-scientific citizens and giving them idle fear when the most prominent experts at that time have made the judgment that there would be no practical danger to our community. Thus scientists are divided in their opinions on the necessity of having dialogues between scientists and citizens. Such a division seems to come from differing views of science that individuals hold.

In 1997 a study group called "Citizens' Participation in Science and Technology", consisting mainly of critics of science, experimentally held a consensus conference of the Denmark method entitled "Meeting of Citizens for Thinking of Gene Therapy"[6]. The consensus conference is one of the methods of technology assessment to be made by ordinary citizens, not experts such as scientists.

You may safely say that there is growing public opinion that citizens should be interested in science, rather than not. The voice comes from not only citizens and science and technology related policy makers, but also from scientists. This section has discussed the attitude towards science and technology that citizens are expected to have. The next section will unfold the author's view of citizens who could commit themselves to science and technology.

2.2 Citizens' attitude on goals of education

One of the goals of science education is how to educate citizens in terms of how they view their relationship with science and technology. This depends on how individuals view education. STS education which utilizes information from the U.K., Canada, the U.S.A., Japan and other Asian countries aims at helping the students understand the interactions of science, technology, and society. STS education is related to environmental education which regards the ways in which science and technology may cause environmental problems in the society[7]. STS education is said to be characterized by value education in which decision making is included in the learning process[8]. It departs from conventional science education in Japan. STS education focuses on increasing the learner's ability to make decisions on STS issues, rather than enabling the learner to acquire scientific knowledge. STS issues include environmental, energy and medical problems which have been caused by science and technology. As the issues are not value free themselves, STS education requires learners to make decisions on environmental issues that involve values.

Ogawa(1998) classifies science into western science, indigenous science, and personal science from the perspective of Horton's "Science as Culture" and discusses their relationships[9]. He also argues that learners should be allowed to choose between (1) western science which is foreign even for westerners and is an edifice of knowledge or (2) the interactions of science with society, the inner system and the nature of the scientific community. Then they should decide which level they are going to learn; (1) recognition (2) understanding, or (3) commitment. He believes that the goals of education should be determined by individual learners. On the other hand, from a viewpoint of critical pedagogy the goal of education is to empower people who are unfairly socially deprived because of the dominant paradigm in modern society[10]. In trying to pursue this goal there is a danger that it is impossible to awaken learners to the necessity of being empowered and they might graduate from schools without recognizing themselves as the oppressed, as public education might reproduce social injustice in the dominant paradigm[11]. Whether such a goal should be pursued through school education or lifelong education leaves the door open to further discussions. At this moment, however, the author does not find it necessary to delay empowering learners by choosing lifelong education.

3. LEARNING IMAGES OF SCIENTISTS THROUGH THE HISTORY OF SCIENCE

3.1 The significance of learning the history of science

Suzuki says that learning the history of science is useful for understanding (1) scientific knowledge and concepts, (2) their developing process and (3) the nature of science[12]. He says that it is possible to include both the history of science and that of science and technology in the curriculum of STS education, as the history of science and technology helps learners understand the nature of science and technology. The author will focus on (3) the nature of science in this paper.

The material to be introduced in the next section describes the subjectivity of scientists, their relations with societal and cultural situations and the way the scientific community works. All this can be seen in their research activities, research methods and their results. Showing how scientists in the past conducted their research allows learners to understand the nature of science.

3.2 What images of scientists are presented in the material?

Conventional science education in Japan has not dealt with the lives of scientists. As a result most of the people might acquire images of scientists through books for school children (biographies in particular), comic books and mass media such as TV programs[13].

The conventional science class might portray scientists as being righteous and excellent persons who have constructed and discovered truthful scientific knowledge and concepts. Such images might be relayed to learners implicitly through a hidden curriculum, as the class aims at acquiring correct scientific knowledge and concepts.

The National Research Council in the U.S.A. presented National Science Education Standards in 1995[14]. "History and the Nature of Science", one of the contents standards indicated by National Science

Education Standards, touched upon enhancing the understanding of "Science as a Human Endeavor." It specifically said, learners were required to understand that "scientists are influenced by social, cultural and personal beliefs and ways of viewing the world" and that "scientists have ethical tradition." Examples of scientists who have allowed the results and conclusions of their research to be influenced by their beliefs and world views are described in the materials developed by the author. Some scientists described in the material support scientific racial discrimination which results in the altering of data either consciously or unconsciously[15][16]. In other words the motivations of scientists and the methods that scientists apply and the results of their research might possibly be influenced by their individual prejudices. Such biased results are not necessarily corrected in scientific communities. This is argued by researchers studying "sociology of scientific communities"[17].

What are good pedagogical grounds for showing learners more realistic images of scientists, rather than portraying images of scientists as always being just and good? When citizens discuss with scientists the way that science and technology are, the relationship between the two parties are expected to be interactive and democratic. But many citizens regard scientists as people who always have correct knowledge. Even though a scientist may lack ethics, it is attributed to his character. Only a few people look for the cause in the inner system of scientific communities. Absence of a good understanding of scientists might prevent citizens and scientists from having sound dialogues. Therefore science education should play a role on changing naive images of scientists that people have to more realistic ones.

4. MATERIAL"HOW SCIENTISTS TO BE : THE HISTORY OF DISPUTE ON THE HEREDITABILITY OF INTELLIGENCE"

4.1 Outlines of the material

This section outlines the material developed by the author in order to provide science education through which students can get more realistic images of scientists (Table Ⅰ).

This teaching material is in the form of a work sheet. A learner is supposed to read on and learn by answering questions. Table Ⅱ shows a specific research method that a scientist used. This time learners were undergraduates of liberal arts. But the author believes high school students could also use the material.

4.2 Students' views of scientists and their changes

Next it is shown how learners' views of scientists have changed after learning the material.

In order to confirm that the images of scientists that students had have changed after learning, experiments were conducted on the group of 160 undergraduates who used the material for learning.

Table Ⅰ Main contents of the material

Plato's biological determinism
Craniology in the 19th century
- racial ranking
- A shared context of culture and society
- unconscious manipulation of data
- the influence of prejudice

Eugenics
IQ test in the 20th century
- Binet's test and Army's test

The case of Sir Cyril Burt
- Fabrication of data
- Never existed collaborator

Today's dispute
Scientists
- The way of research activities
- Scientific communities
- Ethis and social responsibility

Table Ⅱ The material(part)

Morton filled the cranial cavity with shifted white mustard seed, poured the seed back into a graduated cylinder and read the skull's volume in cubic inches. He couldn't obtain consistent results, so he switched to the lead shot.
Then Gould calculated the discrepancies between seed and shot by race.

Table: Discrepancies between seed and shot by race

	blacks	Indians	Caucasians
shot-seed	5.4	2.2	1.8

Q: What is the reason the volume by shot is not the same as one by seed?

Q: why the discrepancies occurred like 5.4>2.2>1.8?

They took tests related to images of scientists both before and after learning. The control group of 28 students had the same tests. Learners answered questions in the Rikert Scale. They were supposed to choose one of the following answers, "disagree", "do not completely disagree", "neither agree nor disagree", "agree to some extent" and "agree" representing scores of −2, −1, 0, +1 and +2 respectively. Scores for each item were added up to get the total score for each scale(Fig.1).

As a result in almost every scale (1) the difference of the average scores of the pretest and posttest (Table Ⅲ) and (2) the difference of the average scores of the posttest and the control group were significant (Table Ⅳ). There was no significant difference between the pretest and the control group. For want of space only part of the results of the experiments is shown.

5. CONCLUSION

This paper has discussed the significance of introducing the history of science in scientific education from the perspective of science studies and pedagogy. Images of scientists that undergraduates had changed significantly after they learned with the material developed by the author. Images of scientists with social credit and who do nothing unfair in their research activities and who do not allow their prejudice to influence their results were more strongly denied after learning. It was also confirmed that students have a stronger image of scientists who interact with society when they do their research.

Social confidence Scale
As scientists have specialized knowledge, they can be trusted.
Scientifically difficult issues are to be left to scientists.
Unfairness Scale
Scientists sometimes deliberately publish the false results of their studies.
Everyone is always convinced that conclusion that scientists reach are right.
Scientists might draw a wrong conclusion from their research.
Prejudice Scale
Scientists are always impartial, when doing their scientific research. (reversed score)
Scientists do not bring their prejudice in their studies. (reversed score)
Influence on society Scale
Research done by scientists does not affect the way of people's living.
Research done by scientists influence social order. (reversed score)
Conclusions of scientific studies do not affect the way people think.
Influence of science Scale
Scientists are less interested in what is going on in society.
Research done by scientists is not influenced by what society values.
Scientists do their research without being affected by societal phenomena.

disagree	do not completely disagree	neither agree nor disagree	agree to some extent	agree
−2	−1	0	+1	+2

Fig.1 Scales and their items(part)

Table Ⅲ Comparison of pretest and posttest

Measure	pretest M	pretest SD	posttest M	posttest SD	t	
Social trust	-0.77	1.67	-1.58	1.68	-5.61	*
Injustice	2.21	1.63	3.67	1.87	9.12	*
Prejudice	0.96	1.52	2.15	1.65	7.54	*
Influences to society	-2.89	1.80	-3.81	1.96	-5.00	*
Influences from society	-1.72	2.08	-2.65	2.31	-4.15	*

*p<0.01

Table Ⅳ Comparison of controls and posttest

Measure	controls M	controls SD	posttest M	posttest SD	t	
Social trust	-0.43	1.64	-1.58	1.68	-3.41	**
Injustice	2.12	1.58	3.67	1.87	4.60	**
Prejudice	1.36	1.20	2.15	1.65	3.02	**
Influences to society	-3.01	1.64	-3.81	1.96	-2.02	*
Influences from society	-1.61	2.17	-2.65	2.31	-4.15	*

**p<0.01 *p<0.05

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(Received January 11, 1999; accepted April 12, 1999)